phase error |I|−|Q| at the output of subtracter 26 and the module of vector (I, Q), expressed approximately by max (|I|, |Q|)+½ min (|I|, |Q|).

The present invention has been described for QPSK modulation, in which two bits are transmitted through two binary signals, but it also applies to other types of modulation for transmitting a plurality of bits, such as QAM modulation, in which each of two quadrature modulated signals may have more than two discrete levels.

Having thus described at least one illustrative embodiment of the invention, various alterations, modifications and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only and is not intended to be limiting. The invention is limited only as defined in the following claims and the equivalents thereto.

What is claimed is:

1. A method for detecting a locked condition of a demodulator operating upon a plurality of QPSK signals that each has at least one discrete level that corresponds to one of a predetermined plurality of nominal points in a constellation plane, wherein the demodulator restores the plurality of QPSK signals by generating a plurality of effective points in the constellation plane, each one of the plurality of effective points corresponding to one of the plurality of QPSK signals, the method comprising the steps of:

(A) defining a plurality of reference areas in the constellation plane, each of the plurality of reference areas being defined between two lines crossing an origin of the constellation plane; and

(B) indicating the locked condition when a percentage of the plurality of effective points generated by the demodulator occurring in the plurality of reference areas is within a range of probability for effective points to occur in the plurality of reference areas when the demodulator is in the locked condition;

wherein step (A) includes a step of defining the plurality of reference areas by a plurality of lines including four lines having slopes of k, 1/k, −1/k, and −k respectively, where k is a real number equal to at least 2;

wherein each one of the plurality of effective points has a first component and a second component, said first and second components corresponding to locations in the constellation plane; and

wherein step (B) includes a step of determining, for each one of the plurality of effective points, whether the one of the plurality of effective points occurs in one of the plurality of reference areas by:

multiplying a minimum value, equal to a lesser of an absolute value of the first component of the one of the plurality of effective points and an absolute value of the second component of the one of the plurality of effective points, by a number greater than 1 to produce a modified value for the one of the plurality of effective points;

subtracting the modified value from a maximum value, equal to a greater of an absolute value of the first component of the one of the plurality of effective points and an absolute value of the second component of the one of the plurality of effective points, to produce a subtraction value for the one of the plurality of effective points; and

analyzing a sign of the subtraction value to determine whether the one of the plurality of effective points occurs in one of the plurality of reference areas.

2. A circuit that detects a locked condition of a demodulator operating upon a plurality of QPSK signals that each has at least one discrete level that corresponds to one of a predetermined plurality of nominal points in a constellation plane, wherein the demodulator restores the plurality of QPSK signals by generating first and second quadrature demodulated signals for each of the plurality of QPSK signals that define a plurality of effective points in the constellation plane, each one of the plurality of effective points corresponding to one of the plurality of QPSK signals, the circuit comprising:

a first absolute value circuit that receives the first quadrature demodulated signal for each of the plurality of QPSK signals and generates a first absolute value of the first quadrature demodulated signal;

a second absolute value circuit that receives the second quadrature demodulated signal for each of the plurality of QPSK signals and generates a second absolute value of the second quadrature demodulated signal;

a comparison circuit, coupled to the first and second absolute value circuits, that receives the first and second absolute values and generates a maximum value and a minimum value for the first and second absolute values; and

a counter that is enabled to count according to a difference between the maximum value and a product of the minimum value and a multiplication factor, the counter having at least one output indicative of the locked condition.

3. The circuit of claim 2, wherein the comparison circuit further comprises a subtraction circuit to subtract the first absolute value from the second absolute value to generate a phase error.

4. The circuit of claim 2, wherein the circuit further comprises

a multiplication circuit that multiplies the minimum value and the multiplication factor to generate the product; and

a subtraction circuit that subtracts the product from the maximum value to generate the difference.

5. The circuit of claim 2, wherein the counter is an up/down counter having a counting mode selected according to a sign of the difference between the maximum value and the product of the minimum value and the multiplication factor.

6. A system for detecting a locked condition of a demodulator that operates upon a plurality of QPSK signals that each has at least one discrete level that corresponds to one of a predetermined plurality of nominal points in a constellation plane, the demodulator restoring the plurality of QPSK signals by generating a plurality of effective points in the constellation plane, each one of the plurality of effective points corresponding to one of the plurality of QPSK signals, the system comprising:

the demodulator; and

means for indicating the locked condition when a percentage of the plurality of effective points generated by the demodulator occurring in a plurality of reference areas in the constellation plane is within a range of probability for effective points to occur in the plurality of reference areas when the demodulator is in the locked condition, each of the plurality of reference areas being defined between two lines crossing an origin of the constellation plane.

* * * * *